

Possible avian predation on *Furcula furcula* cocoons (Lepidoptera, Notodontidae) at an urban park

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Abstract We observed the cocoons of *Furcula furcula* (Clerck) (Lepidoptera, Notodontidae), which were predated at an urban park in Osaka Prefecture in central Japan. The predated cocoons included two types that bore pupal fragments or none inside, possibly indicating different predation modes by birds. Most of the cocoons were attacked, with the predation rates being 97.4% ($N=117$) on January 10, 2002, and 88.4% ($N=69$) on April 1, 2004, although the cocoon distribution pattern varied between the examination dates. The host trees were regularly planted along an avenue, and the twigs on their trunks were cleared every winter. Therefore, the predators could efficiently forage for *F. furcula* cocoons.

Key words Urban ecology, city park, avian predation, cocoon, *Furcula furcula*.

Introduction

Birds are important predators of various lepidopteran species (Itô & Miyashita, 1968; Holmes *et al.*, 1979; Shiga, 1979; Hooks *et al.*, 2003). However, most studies to date which examined bird predation on Lepidoptera have focused on the adult (*e. g.* Kettlewell, 1961; Sargent, 1973; Pouch & Brower, 1977; Smith, 1979; Johki, 1985; Tsubuki & Ueda, 2001) and larval stages (*e. g.* Tinbergen, 1960; Holmes *et al.*, 1979; Moore & Hanks, 2000; Hooks *et al.*, 2003), whereas bird predation on the pupal or prepupal stages has not been well-examined (but see Waldbauer & Sternburg, 1967; Waldbauer *et al.*, 1970; Battisti *et al.*, 2000).

Urban trees and ornamental plantings often suffer from severe insect herbivory (*e. g.* Itô & Miyashita, 1968; Dreistadt *et al.*, 1990). To control insect pests in urban settings, exploration of the interactions between insects and natural enemies may be important.

Furcula furcula (Clerck) (Lepidoptera, Notodontidae) is a medium-sized (wing span: 33–36 mm) prominent moth whose larva feeds on the leaves of willows and poplars (Okagaki, 1958; Sugi, 1982). The mature larva crawls down the tree trunk, makes a hard cocoon in a crevice and then pupates (Fig. 2). *F. furcula* hibernates as a pupa. The moth emerges from May to September with three or more generations per year in the warm temperate regions of Japan (Okagaki, 1958; Sugi, 1982; Yamazaki, *pers. obs.*).

We found that the cocoons of the notodontid moth are frequently predated, possibly by birds at an urban park, and in this report we describe the characteristics of the predated cocoons and as well as their predation rates.

Materials and methods

Field observations were carried out at Tsurumi-ryokuchi Park (34°42'N, 135°35'E, ca 5 m a. s. l., 162 ha), an urban park, in Moriguchi City, Osaka Prefecture in central Japan.

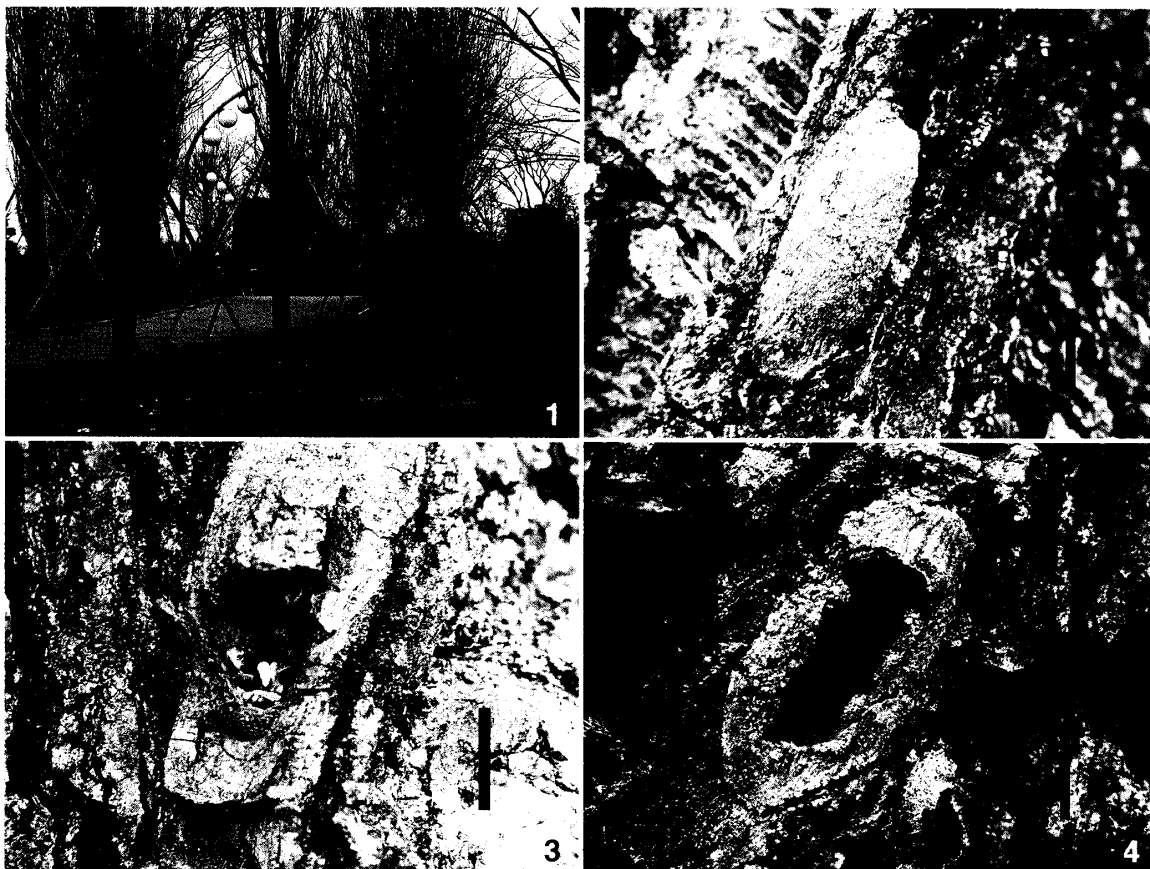


Fig. 1. Study site: a poplar avenue at Tsurumi-ryokuchi Park.

Figs 2–4. *Furcula furcula* cocoons on the tree trunk. 2. Intact cocoon. 3. Attacked cocoon with pupal fragments. 4. Attacked cocoon without pupal fragments. Scale lines: 10 mm.

Across a grass field in the western part of this park, there exists an avenue (*ca* 300 m long) of poplar *Populus nigra* var. *italica* (Salicaceae) (Fig. 1), where *F. furcula* cocoons were found. The poplar trees were planted in two rows along the avenue. The nearest distance between trees of the same rows was 6.5 m and the rows lay 10.5 m apart. The lower twigs of the trees were cleared away every winter. The trees were 8–10 m tall and their DBH (diameter at breast height) ranged from 25–45 cm. We observed predated cocoons of this moth and examined the predation rates for all of the trees ($N=76$) on January 10, 2002, and April 1, 2004. The number of *F. furcula* cocoons on each trunk and the presence/absence of attack marks on each cocoon was recorded at a height of 0–3 m above the ground. The cocoons examined were restricted to new cocoons of the current-year overwintering generation based on their appearance, where the cocoon surface was rough, and the cocoon surface adhering to the ambient bark was often obscured by the presence of silky threads. In addition, the inside color of the new cocoons was light brown or reddish brown (Figs 2–4).

The predation rate was compared between the examination days using Fisher's exact test. The distribution patterns of *F. furcula* cocoons among the trees for each observation were analyzed using Morisita's aggregation index (Morisita, 1959), which is defined as

$$I_{\delta} = Q \sum_{i=1}^Q x_i(x_i - 1) / N(N - 1)$$

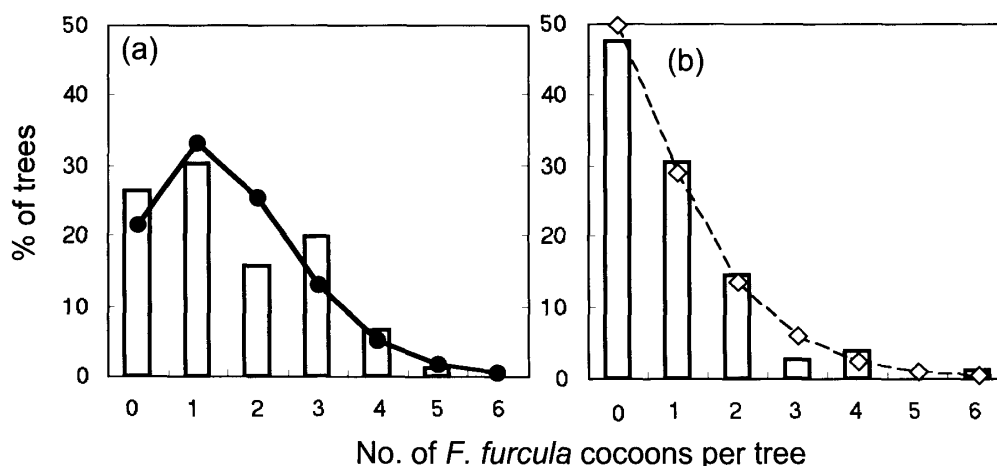


Fig. 5. Distribution of *Furcula furcula* cocoons among poplar trees in (a) January 2002, and (b) April 2004 ($n=76$ for both years). Bars represent cocoon distribution patterns observed. Closed circles show the expected values calculated from a Poisson distribution. Open diamonds show the expected values from a negative binomial distribution (one of contagious distributions).

Here, Q is the total number of quadrats (*i. e.*, tree trunks of 0–3 m in height), x_i is the number of cocoons in the i th quadrat ($i=1, 2, 3, \dots, Q$), and N is the total number of cocoons. If the observed I_δ is significantly <1 or >1 (F -test), the distribution pattern is considered to be uniform or aggregated, respectively, and if the observed value is not significantly different from 1, the distribution pattern is determined to be random.

Spatial distribution of the cocoons may affect predation. Therefore, logistic regression analyses were used to predict predation on a cocoon by the number of cocoons occurring together on the same tree.

Results

Many *F. furcula* cocoons bore irregular-shaped openings caused by predation on both examination days (*cf.* Figs 2–4). Some of the attacked cocoons had fragments of the pupal integument left inside (Fig. 3) and others had lost the entire pupal or prepupal bodies (Fig. 4). Also, the latter cocoons had wider openings than did the former ones.

The predation rate was 97.4% ($N=117$) for January 10, 2002 and 88.4% ($N=69$) for April 1, 2004. The predation rate was not significantly different between examination days (Fisher's exact test, $d.f.=1$, $P=0.0792$).

The distribution of *F. furcula* cocoons among the trees was random in 2002 ($I_\delta=1.09$, $d.f.n_1=75$, $d.f.n_2=\infty$, $F=1.15$, $P=0.05$) (Fig. 5a), while it was aggregated in 2004 ($I_\delta=1.62$, $F=1.56$, $P<0.01$) (Fig. 5b). Most non-predated cocoons (all three in 2002 and five of eight in 2004) were singly located on a tree. However, predation on a cocoon could not be predicted by the number of cocoons occurring together on the same tree (logistic regression analyses, $d.f.=1$, $\chi^2=0.0002$, $P=0.989$ for 2002, $\chi^2=0.0393$, $P=0.843$ for 2004).

Discussion

1) Possible avian predation and tentative avian species

We did not observe the moment of predation on *F. furcula* cocoons in the present study. However, we deduced that the predators were birds, since no insectivorous mammals could open the hard cocoons at the study site, and because the wounds inflicted on the cocoons appeared to be due to bird beaks rather than rodent teeth (Figs 3–4).

The pecked cocoons included two types: one with pupal fragments and the other without fragments (Figs 3–4). This finding reflects the existence of two different methods of predation; the predators might destroy the cocoons and simultaneously crush the pupae to consume internal tissues, or they might tear open the cocoons and remove the entire pupae. It is unclear whether this difference in the form of predation reflects a difference between predator species or individuals.

Moore & Hanks (2000) documented that in Illinois, USA, the English sparrow *Passer domesticus* preys on the evergreen bagworm *Thyridopteryx ephemeraeformis* (Haworth) (Lepidoptera, Psychidae) by squeezing out the guts and haemolymph of bagworm larvae from the bags. The tree sparrow *Passer montanus* preys on the pupae or prepupae of the tent caterpillar *Malacosoma neustria testacea* (Motschulsky) (Lepidoptera, Lasiocampidae) by tearing open the cocoons to remove the entire pupae or by pecking at the edge of the cocoons to suck out internal pupal tissues in Osaka, central Japan (Yamazaki, *pers. obs.*). Thus, the feeding modes of predators seem to be variable among species and even within the same species.

On the assumption that the predators that attacked *F. furcula* cocoons were avian species, which were the species involved? Several species of woodpecker efficiently forage and prey on the cocoons of *Hyalophora cecropia* (L.) (Lepidoptera, Saturniidae) in winter in Illinois, USA by making small holes in the cocoons to remove internal pupal tissues using the tongue (Waldbauer & Sternburg, 1967; Waldbauer *et al.*, 1970). At our study site, the Japanese pygmy woodpecker *Picoides kizuki* has occasionally been observed (Wild Bird Society of Japan, Osaka Branch, Bird-Watching Party, 1995). However, the wounds inflicted on *F. furcula* cocoons observed in this study (Figs 3–4) were unlikely to be caused by woodpeckers judging from the size and shape of the openings.

In the winter in city parks across central Japan, the great tit *Parus major*, a common bird species, attacks *Parasa lepida* (Cramer) (Lepidoptera, Limacodidae) cocoons which are spun on tree trunks (Yamazaki, *pers. obs.*). In addition, Sakuratani (2001) reported that the varied tit *Parus varius* preys on *Monema flavescens* Walker (Lepidoptera, Limacodidae) prepupae in their cocoons during winter in Nara, central Japan. Therefore, we deduce that several tits (*Parus* spp.) must have predated on *F. furcula* cocoons.

2) High predation rates during the winter in urban settings

Although the cocoon distribution patterns varied somewhat between the examination days (Fig. 5), most of the cocoons were predated in this study. This suggests that the predation pressure on lepidopteran cocoons becomes severe from late autumn to early spring. As mentioned above, the hairy and downy woodpeckers *Dendrocopos villosus* and *D. pubescens* prey on the cocoons of several saturniids including *H. cecropia* in urban environments in Illinois, USA during late autumn and winter (Waldbauer & Sternburg, 1967; Waldbauer *et al.*, 1970). Since from late autumn until winter prey for insectivorous predators is scarce, lepidopteran cocoons may become the target of predators.

The predation rates (97.4% in 2002 and 88.4% in 2004) observed in this study may be interesting values, when taking into account the lack of natural enemies present in urban settings. However, the host trees are regularly planted along the avenue, and the twigs on their

tree trunks are cleared away every winter (Fig. 1). Therefore, predators (possibly birds) can efficiently forage for *F. furcula* cocoons.

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摘 要

都市公園におけるナカグロモクメシャチホコ繭の捕食 (山崎一夫・杉浦真治)

ナカグロモクメシャチホコ *Furcula furcula* (Clerck) はヤナギ科植物を寄主とし, 年に3化以上経過し, 寄主の幹で繭を作り, その中で蛹越冬する. 大阪の都市公園のポプラ並木で, 冬季と早春に, 捕食された本種の繭を観察した. 繭に残された傷跡や公園の動物相から, 捕食はカラ類などの野鳥によると推測された. 捕食跡のある繭には, 内部に蛹殻の破片を含むものと含まないものがあった. この違いは捕食者(鳥)による蛹の摂食に二つの方法があることを示すのかもしれない. 繭の樹木間の分布パターンは調査年度により多少変化した, 繭の捕食率は, 2002年1月10日には97.4% ($N=117$), 2004年4月1日には88.4% ($N=69$) に達した. 調査地のポプラは道路に沿って規則的に配置され, 冬季には下枝が切り払われるので, 野鳥は効率よく本種の繭を発見し採餌できたのであろう.

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